Fabric and Cordage Examinations

1 Scope

This document describes procedures used by Fiber Examiners in the examination of fabric and cordage characterization, identification, and comparison in the Trace Evidence Unit (TEU) and Scientific and Biometrics Analysis Unit-Trace (SBAU-Trace). Examination of fabric damage, fabric impressions, and the fabric portion of tape are included in these procedures. The nature and extent of the evidence will determine the techniques used.

2 Equipment/Materials/Reagents

- Comparison microscope, magnification range from approximately 40x to approximately 600x
- Stereobinocular microscope, magnification range from approximately 2x to approximately 40x
- Keyence digital microscope, magnification range from approximately 5x to approximately 1000x (SBAU-Trace)
- Forceps
- Spatula
- Scissors
- Probes
- Digital Camera
- Lux-o-lamp®
- Substrate for producing test damage *e.g.*, Cardboard box or Styrofoam
- Iron
- Sonicator

3 Standards and Controls

Not applicable.

4 Sampling

Known fiber sample selections will represent the range of fibers of different colors, shapes, and sizes comprising the fabric and/or cordage. The comparison of the composition of the fabric and/or cordage will be based on these sample selections.

5 Procedure

5.1 Fabric Examinations

5.1.1 Prior to a fabric analysis, specimens may be processed utilizing the procedures outlined in the respective unit's *Evidence Processing Procedures*.

5.1.2 The general appearance, stains, size, shape, color, and condition of the pieces of fabric will be documented. The documentation will also include any cut, torn, crushed, or burned edges. After the condition of the fabric is documented, it may be necessary to clean and/or iron the fabric in order to accurately examine it.

5.1.2.1 Cleaning may be conducted with water and soap and may involve sonicating the fabric. The fabric will be allowed to air dry and then ironed if necessary to allow for accurate thread counts and comparison of edges. Care will be taken to ensure the integrity of the fabric.

5.1.3 The type of fabric (*e.g.,* woven, knit, or non-woven) will be documented.

5.1.4 Any identifying characteristics which may help identify the possible end use of the textile (*e.g.,* trousers, jacket) will be documented.

5.1.5 An examination should be conducted for obvious macroscopic characteristics, such as repeats or manufacturer's flaws, a missing portion of a printed design, a thicker yarn, stains, etc. Dimensions (*e.g.*, selvedge edge to selvedge edge, if present) may be determined to calculate a maximum width.

5.1.6 The size and shape of any missing portion(s) from each piece of fabric should be determined, if possible, and documented.

5.1.7 The thread count, color, and construction of yarns in the fabric will be determined and documented.

5.1.8 A known fiber sample(s) representative of the fabric may be taken and mounted on a glass microscope slide.

5.2 Fabric Comparisons

5.2.1 Any obvious macroscopic characteristics that may serve to quickly eliminate the pieces of fabric as having come from a common source will be compared. These characteristics may include repeats, manufacturer's flaws, differing maximum widths, a missing portion of a printed design, a thicker yarn, stains, etc.

5.2.2 The corresponding "side" or "face" of the fabric will be determined, if possible, and the warp and weft yarns (or courses and wales) will be oriented in the same direction for comparison.

5.2.3 Using macroscopic characteristics such as irregular contours from cuts and/or tears, different types, sizes, and colors of yarns, design patterns, and stain patterns, an attempt to orient the pieces of fabric to one another will be made and a determination will be made as to whether the two pieces appear to physically fit together. The size of the area missing from one piece of fabric should be equal to or greater than that of the other fabric.

5.2.3.1 Once the pieces of fabric are oriented using macroscopic characteristics, individual yarns should be compared to one another, ensuring that the "long" yarns in one fabric coincide with the "short" yarns in the other piece of fabric. Comparisons of yarns should continue along the entire cut or torn edge.

5.2.3.2 If all of the gross characteristics and all of the "long and short" yarns along the entire cut or torn edge of one piece of fabric can be associated to the second piece of fabric, it can be concluded that the two pieces of fabric physically match one another and at one time were a contiguous piece of fabric.

5.2.3.3 Diagrams and/or photographs of the two pieces of fabric together will be taken, marked with the laboratory number(s) and item numbers, and retained in the notes.

5.2.3.4 If the two pieces of fabric physically fit together, they must also be alike in color, construction, and composition. Therefore, no additional fabric comparisons between the two physically matched pieces of fabric are necessary.

5.2.4 If two pieces of fabric do not physically match to one another, an examination to determine if the two pieces of fabric exhibit the same color, construction, and composition will be conducted.

5.2.4.1 The thread count, color, and construction of yarns in each direction for each piece of fabric will be documented and compared.

5.2.4.2 If no difference are observed in the construction of the fabric, the fibers comprising the fabric will be identified and compared utilizing the procedures outlined in the *Forensic Fiber Examinations* protocol.

5.2.4.3 If no differences are observed between the fibers comprising the pieces of fabric and the appropriate techniques outlined above, it can be concluded that the pieces of fabric are consistent with originating from the same item or from two different items exhibiting the same color, construction, and composition.

5.3 Fabric Impression Examinations

5.3.1 Examination may be of the questioned item bearing the actual impression, a "lift" of an impression, a "cast" of an impression from various types of surfaces (*e.g.*, mud, glass, fender) or a photograph of an impression. If the actual item bearing the impression is submitted and hair

and fiber examinations have been requested, the item will first be examined for the presence of trace evidence utilizing the procedures outlined in the respective unit's *Evidence Processing Procedures*, if appropriate.

5.3.1 Identifying features that may help in the identification of the fabric type (*e.g.*, twill, plain weave, knit, etc.) of the potential donor will be studied and documented.

5.3.2 Damaged areas on the fabric item (*e.g.*, cuts, tears, snags) that may aid in orientation of the fabric and may add significance to the association will be identified and evaluated.

5.3.3 Multiple impressions of the potential fabric donor on a suitable substrate such as ink or modeling clay may be created, using different amounts of force or pressure.

5.3.4 The number of yarns or loops per inch in each direction for both the known fabric impression and the questioned impression will be compared. Results will be documented in the case notes.

5.3.5 If no differences are observed between the known fabric impression and the questioned impression, it can be concluded that the fabric or another fabric of similar construction could have made the impression. The presence of characteristics such as cuts, tears, snags, etc., may allow for added significance to the conclusion.

5.4 Fabric Damage Examination

5.4.1 Prior to a fabric damage analysis, specimens are typically processed utilizing the procedures outlined in the respective unit's *Evidence Processing Procedures*. Fabric damage (*e.g.*, length of cut/tears), any identifying features (*e.g.*, single edged blade characteristic "V" shaped notch from the flat edge tearing the fabric), the shape of the cut/tear, and any other characteristics observed will be documented.

5.4.2 When possible, test damage will be created after all other appropriate laboratory examinations (*e.g.*, trace evidence, DNA, latent print) have been completed.

5.4.2.1 Test damage will be made in an undamaged portion of the garment utilizing the questioned implement(s).

5.4.2.2 The length, shape and overall pattern produced by the test damage will be compared to previously identified fabric damage.

5.4.2.3 Photographs will be taken and maintained with the notes.

5.4.2.4 If no differences are observed between the test damage and the questioned fabric damage, it can be concluded that the identified fabric damage is consistent with having been made by the questioned implement or another similar implement.

5.5 Tape with Fabric Components Examinations

5.5.1 Prior to the analysis of the fabric component of tape, to include duct tape, specimens are typically processed utilizing the procedures outlined in the respective unit's *Evidence Processing Procedures*, if appropriate.

5.5.2 The fabric component of tape is examined, and if necessary compared, by fiber examiners to determine its color, construction, and composition. The fabric portion of the duct tape or fabric backing of fabric tape is examined by fiber examiners to determine color, construction and composition. The Chemistry Unit is responsible for the analysis of the remainder of the duct tape or fabric tape.

5.5.3 The thread count, color, and construction of yarns (warp and weft) for the fabric component of each piece of tape will be documented and compared.

5.5.4 The fibers present in the warp and weft yarns will be analyzed and identified utilizing the procedures outlined in the *Forensic Fiber Examinations* protocol.

5.5.5 If the item received for analysis encompasses the entire width of the tape and at least 1 inch of the length of the tape, and if no differences are observed between the pieces of fabric utilizing the appropriate techniques outlined above, it can be concluded that the fabric components of the tape are consistent with originating from the same source or from two different sources exhibiting the same color, construction, and composition.

5.5.5.1 If the item received for analysis does not encompass the entire width of the tape and at least 1 inch of the length of the tape, and if no differences are observed between the pieces of fabric utilizing the appropriate techniques outlined above, it can be concluded that the fabric components of the tape exhibit the same color, construction and composition as one another, and therefore are consistent with originating from the same source or from two different sources exhibiting the same color, construction, and composition. However, a statement will be added to the results identifying that the piece of tape received for analysis was not sufficient to fully characterize the tape.

5.6 Cordage Examinations

5.6.1 Prior to a cordage analysis, specimens are typically processed utilizing the procedures outlined in the respective unit's *Evidence Processing Procedures*, if appropriate.

5.6.2 The general appearance, stains, size, shape, color and condition of the pieces of cordage will be analyzed and documented paying special attention to cut, torn, crushed or burned edges.

5.6.3 The ends of the pieces of cordage will be examined to determine how the cordage was severed (*e.g.*, cut, burned, torn), if appropriate.

5.6.4 After the condition of the cordage is documented, it may be necessary to clean the cordage in order to accurately examine it.

5.6.4.1 Cleaning may be conducted with water and soap and may involve sonicating the cordage. The cordage will be allowed to air dry. Care will be taken to ensure the integrity of the cordage.

5.6.5 The diameter (and length, if pertinent), type of cordage (twisted or braided) will be documented and any knots that are present noted, if pertinent.

5.6.6 The number of crowns or turns per inch, the number of plies and braids, and the direction of twist ("S" or "Z") for the entire piece of cordage and for each ply or braid will be documented.

5.6.7 A known fiber sample(s) representative of the cordage may be taken and mounted on a glass microscope slide.

5.7 Cordage Comparisons

5.7.1 Any obvious macroscopic characteristics that may serve to quickly eliminate the pieces of cordage as having come from a common source will be compared. These characteristics may include repeats, manufacturer's flaws, differing widths, a missing portion of a design, a thicker ply, etc.

5.7.2 A determination will be made as to the suitability of the ends of the cordage for physical matching. Individualizing characteristics on the ends of the cordage such as a paper core or jagged plastic edges will be examined.

5.7.2.1 If the cordage has a paper or fabric core, the core will be opened so that it lays flat on the workspace.

5.7.2.2 Using macroscopic characteristics such as irregular contours, different types, sizes and colors of yarns, design patterns and stain patterns, orientation of the cores to one another will be attempted.

5.7.2.3 Once the cores are oriented using macroscopic characteristics, comparisons of the individual components of the cores to one another will be conducted. If the core is fabric, the comparisons will follow the fabric comparison procedures above. If the core is paper, comparison of the cut and/or torn edges to one another will be conducted along the entire length of the core.

5.7.2.4 If no differences can be found between the two pieces of core, then it can be concluded that the two pieces of core physically match one another and were once joined across their severed ends.

5.7.2.5 Diagrams and/or photographs of the two pieces of cordage together will be made, marked with the laboratory number(s) and item numbers, and retained in the notes.

5.7.2.6 If two pieces of cordage physically match one another, then they must also be alike with respect to color, construction and composition. Therefore, no additional cordage comparisons between the two physically matched pieces of cordage are necessary.

5.7.3 If two pieces of cordage cannot be physically matched to one another, examinations will be conducted determine if the two pieces of cordage exhibit the same color, construction and composition.

5.7.3.1 A measured section may be removed (*e.g.*, one inch) from a logical area (not near the end, a knot, etc.), and the remaining cut ends taped together and marked appropriately. This "section" may be used for determination of construction and composition.

5.7.3.2 The color and construction (*e.g.*, crowns per inch, number of plies/braids, twist of plies/braids) for each piece of cordage will be documented.

5.7.3.3 Each piece of cordage will be examined for a core or a tracer. If so, the construction of the core or tracer will be documented in the case notes.

5.7.3.4 The fibers comprising each piece of cordage will be analyzed and identified utilizing the procedures in *Forensic Fiber Examinations* protocol.

5.7.3.5 If no differences are observed between the pieces of cordage utilizing the appropriate techniques outlined above, it can be concluded that the pieces of cordage are consistent with originating from the same item or from two different items exhibiting the same color, construction, and composition.

5.8 Fabric, Fabric Damage, Fabric Impression, Tape with Fabric Components, and Cordage Verifications

Fabric, fabric damage, fabric impressions, tape with fabric components, and cordage associations are verified by a second qualified Examiner. These verifications are documented by the signature of the verifying Examiner and the date of the verification on the Verification Form for Legacy cases or documented in Forensic Advantage (FA).

6 Calculations

Not applicable.

7 Measurement Uncertainty

Not applicable.

8 Limitations

The type of information which can be developed as a result of fabric, fabric impression, fabric damage, and cordage examinations is dependent on the type of evidence received and the condition of the evidence.

9 Safety

9.1 While working with physical evidence, laboratory personnel will wear appropriate protective attire (at a minimum, laboratory coat and gloves).

9.2 Universal precautions will be followed.

9.3 No specific hazards are associated with the examination techniques performed.

10 References

- Hatch, Kathryn L., Textile Science, West Publishing Company, Minneapolis/SaintPaul, New York, Los Angeles, San Francisco, 1993.

- Reader's Digest Complete Guide to Sewing, The Reader's Digest Association, Inc. Pleasantville, New York, 1976.

- Cordage Directory, Published by the Cordage Institute, Hingham, Massachusetts, 1989.

- Registered Numbers & Wool Products Label Encyclopedia, The Salesman's Guide, A Unit of the Cahners Business Information, New Providence, New Jersey, 1998.

Rev. #	Issue Date	History
3	10/02/2017	Removed Unit references throughout document, except where still needed to denote that TEU and SAU-Trace have separate Evidence Processing Procedures. Section 2 Updated equipment used. Section 4 Deleted and renumbered subsequent sections. Sections 5.1.2 and 5.1.2.1 Indicated that fabric may be cleaned and added section about cleaning fabric if necessary prior to examinations. Section 5.1.5 Reworded section for clarity. Section 5.1.6 Reworded section for clarity. Sections 5.1.7 and 5.1.8 Added sections to have information about the yarns recorded and to potentially mount a known fiber sample. Section 5.2 Added Fabric Comparison title. Sections 5.2.1 and 5.2.3 Added sections. Section 5.2.2 Reworded section for clarity. Section 5.2.3.4 Reworded section to indicate that no further examinations need to be performed between two pieces of fabric that physically match. Section 5.2.4.1 Updated section to document thread count, color and construction of fabric. Section 5.2.4.2 Updated section to indicate procedures used to compare fibers. Section 5.2.4.3 Updated section for clarity in conclusion. Section 5.3.1 Updated section to clarify when the items need to be processed for the presence of trace evidence. Section 5.5.2 Updated section for clarity. Section 5.5.3 Updated section to clarify that what characteristics of the fabric will be documented. Sections 5.6.4 and 5.6.4.1 Added sections indicating that cordage may be cleaned and added section about cleaning cordage if necessary prior to examinations. Section 5.6.7 Added section regarding collection of known fiber sample from cordage. Section 5.7.1 Added section regarding macroscopic observations of cordage. Section 5.7.2 Added section regarding assessment of the ends of cordage for physical matching. Section 5.7.2.6 Reworded section to indicate that no further examinations need to be performed between two pieces of cordage that physically match. Sections 5.7.3.2, 5.7.3.3, and 5.7.3.4 Added and updated sections to clarify characteristics to be documented in notes during examination. Section 5.7.3.5 Updated section for clarity in conclusion.

		Changed confirmation to verification throughout document.
4	02/10/2020	Removed fabric damage, fabric impressions, and duct tape from title. Updated SBAU-Trace group name throughout. Changed all references to duct tape to tape with fabric components. Added sampling information into Section 4. Updated language in Section 5.2.2, 5.2.3, 5.2.4, 5.2.4.2, 5.2.4.3, 5.3.4, 5.3.5, 5.7.2.3, 5.7.2.4 for clarity. Updated wording in Sections 5.5 and 5.8 for clarity and to be more general about tape containing a fabric component. Changed language in 5.3.5 removing the ability to ability to make a positive identification. Updated document title in Section 5.7.3.4. Updated QA document titles throughout.

Approval

Redacted - Signatures on File

Trace Evidence Unit Chief: Date: 02/07/2020

Scientific and Biometrics Unit Chief Date: 02/07/2020

Hairs and Fibers Technical Leader: Date: 02/07/2020

Forensic Fiber Examinations

1 Scope

This document describes the procedures for the microscopic examination, identification, and comparison of fiber evidence by Fiber Examiners within the Trace Evidence Unit (TEU) and Scientific and Biometrics Analysis Unit – Trace (SBAU-Trace). The procedures apply to fiber samples that have been previously removed from evidentiary items and have been mounted on glass microscope slides utilizing the respective units *Evidence Processing Procedures* and the *Evidence Handling Procedures*. The acceptance criteria and conclusions regarding associations are also described in this document.

2 Equipment/Materials/Reagents

- Comparison microscope, magnification range approximately 40x to approximately 600x
- Polarized light microscope, magnification range approximately 40x to approximately 400x, with eyepiece reticle
- Fluorescence microscope, four filter combinations encompassing Ultraviolet (UV), Violet, Blue, and Green wavelength regions
- Stereobinocular microscope, magnification range approximately 2x to approximately 40x
- Microspectrophotometer (MSP): Craic MSP 121, Craic QDI 2010 or equivalent
- Fourier Transform Infrared (FT-IR) Spectrometer with microscope attachment: Nicolet 6700 Continuμm, Nicolet is50, or equivalent
- Diamond compression cell
- Xylene substitute, Xyless, or Xylene®
- Glass microscope slide(s) and cover slip(s)
- Quartz microscope slide(s) and cover slip(s)
- Glycerin
- Ethanol
- Permount® mounting medium
- Microscope camera
- Probe, scalpel, forceps
- Berek compensator (or equivalent compensator such as a sliding wedge)
- Full wave (lambda) plate

3 Standards and Controls

3.1 Microspectrophotometry

Refer to the *Performance Monitoring Protocol for Microspectrophotometers* for the steps involved in the performance verification prior to running casework samples on the MSP.

3.2 Fourier Transform Infrared

Refer to the *Performance Monitoring Protocol for FT-IR Systems* for the steps involved in the performance verification prior to running casework samples on the FT-IR.

4 Sampling

Individual fibers are selected from the specimen at the discretion of the Forensic Examiner. These individual fibers may not necessarily be representative of the entire specimen. Fibers may be chosen based on the need to identify a particular component by a specific technique and by its availability or presence in a specimen. If multiple fibers exhibiting the same microscopic characteristics have been identified from the same specimen, one or more may be selected at the discretion of the Forensic Examiner for further examination and comparison of the optical properties, microspectrophotometry, and FT-IR, as appropriate.

5 Procedure

5.1 Documentation of Fiber Evidence

5.1.1 The presence or absence of fibers can be determined based on a microscopic examination of the glass microscope slide(s) containing debris recovered from an item, or group of items, of evidence. The absence of fibers will be recorded in the case notes with a statement such as “no fibers were found” or the absence of any reference to fibers on an item implies no fibers are present.

5.1.2 If fibers are present, they can be identified individually or collectively at the discretion of the Forensic Examiner. Refer to the *Trace Evidence Quality Manual, Abbreviations* list for approved abbreviations for fibers. At a minimum, a general statement regarding the presence of fibers will be recorded in the case notes.

5.1.3 If fiber examinations are not conducted for items of evidence, statements such as “no fiber exams” or “hair exams only” will be used as documentation in the case notes.

5.2 Fiber Comparison

5.2.1 A comparison microscope will be used to compare fibers to one another. The fiber samples will be compared at the same time in the same field-of-view utilizing the comparison microscope.

5.2.2 If the microscopic characteristics including general size, shape, configuration, and color of the fibers are the same utilizing the comparison microscope, the optical properties of the fibers may be analyzed and compared using polarized light microscopy and fluorescence microscopy. Some of these characteristics apply only to manufactured fibers and are identified below. If an unexplainable difference is found for any of these characteristics listed below, the comparison process will cease, and the fibers cannot be associated to each other. This information will be recorded on the Fiber Chart (Appendix A). The general classification of manufactured fibers can usually be determined based on the optical properties of the fiber. Natural fiber type can usually be determined based on the microscopic characteristics of the fiber.

- Fiber Color
  - The fiber color may be uniform or may vary along the length of the fiber. Record the color and any apparent variation in the color, if present. This characteristic applies to both natural and manufactured fibers.
- Fiber Luster
  - The presence, absence, and relative abundance of delustrant present in manufactured fibers will be recorded. This characteristic applies only to manufactured fibers.
- Fiber Cross-Section
  - Record the apparent cross-sectional shape of the fiber. This can be conducted via optical cross-sectioning or by physically cross-sectioning the fiber. This characteristic typically only applies to manufactured fibers, although it may be useful in the identification of certain types of natural fibers.
- Fiber Diameter
  - The approximate diameter of fibers can be measured using an eyepiece reticle. If fiber diameter is variable within a sample, documentation of the diameter range is recommended. This characteristic typically only applies to manufactured fibers.
- Other Characteristics
  - Record any surface damage, manufacturing striations, or other characteristics noted in the sample.
- Becke Line
  - The determination of n-parallel and n-perpendicular relative to Permount® based on the direction of movement of the Becke line in relation to the fiber using plane polarized light. This characteristic typically only applies to manufactured fibers.

- Retardation (Path Difference)
  - The retardation will be determined through the use of a Berek compensator (or equivalent). This characteristic typically only applies to manufactured fibers.
- Birefringence
  - The birefringence can be estimated by dividing the retardation by the diameter of the fiber. A full-wave plate may be used to help determine the sign of elongation. This characteristic typically only applies to manufactured fibers.
- Pleochroism (Dichroism)
  - The presence and/or degree of pleochroism present in a sample will be recorded. This characteristic applies to both natural and manufactured fibers.
- Fluorescence
  - At each of the four excitation wavelengths (Ultraviolet, Violet, Blue, and Green) the color and intensity or the absence of fluorescent emission will be recorded. This characteristic applies to both natural and manufactured fibers.
- Other techniques
  - Other identification and comparison techniques such as micro-solubility examinations or drying twist test may be used as deemed appropriate by the Forensic Examiner. The technique used and the results will be recorded in the case notes.

5.3 Microspectrophotometric Analysis

If fibers exhibit the same microscopic characteristics and optical properties utilizing the characteristics listed above, they may be compared using microspectrophotometry. Colored fibers will be analyzed in the visible (380nm-800nm) region. When information in the visible region is limited, or at the discretion of the Forensic Examiner, fibers may be analyzed in the ultraviolet (240nm-380nm) region.

5.3.1 Sample Spectra Collection – Visible Region

The following procedure is applicable to the Craic QDI 2010, and Craic MSP 121 or equivalent microspectrophotometers.

5.3.1.1 Set the instrument parameters to include analysis in the visible region (380nm – 800nm).

5.3.1.2 Focus on the sample slide with the collection aperture adjacent to the fiber to be analyzed. Ensure the best integration time for scanning is set.

5.3.1.3 Collect a Dark Scan.

5.3.1.4 Collect a Reference Scan. Note: A new Reference Scan must be collected if the stage is moved more than one field-of-view away from the position of the last Reference Scan, a new sample slide is introduced, or if changes are made to the optical settings (e.g., new objective, source intensity, Köhler illumination).

5.3.1.5 Move the fiber to be analyzed under the collection aperture. Collect a Sample Scan.

5.3.1.6 Collect at least five (5) spectra from each manufactured fiber sample to be compared. Collect at least ten (10) spectra from each natural fiber sample to be compared. Save the results in an appropriate electronic folder.

5.3.1.7 The Forensic Examiner may compare a single spectrum which best represents the samples collected or a mean spectrum of all the samples collected. Similar types must be compared (single spectrum compared to single spectrum or mean spectrum compared to mean spectrum). If spectra containing the mean are printed or saved electronically, the word "mean," or the letters "mn," must be part of the text describing the spectra.

5.3.1.8 For Legacy cases, all of the spectra generated will be printed and included in the case notes. In the event of large numbers of spectra, instead of printing the spectra, a CD may be burned with the data for inclusion in the case notes. For Forensic Advantage (FA) cases, the spectra will be imported into the Case Record Object Repository. Spectra must include the FBI Laboratory number(s), specimen number(s), the date of collection, and the operator's initials.

5.3.2 Sample Spectra Collection – Ultraviolet Region

The following procedure is applicable to the Craic QDI 2010 and Craic MSP 121 or equivalent microspectrophotometers.

5.3.2.1 Remove the fiber from the glass microscope slide, remount the fiber on a quartz microscope slide, and cover it with a quartz cover slip using glycerin as the mounting medium.

5.3.2.2 Set the instrument parameters to include analysis in the ultraviolet region (240 nm - 380 nm).

5.3.2.3 Focus on the sample slide with the collection aperture adjacent to the fiber to be analyzed. Ensure the best integration time for scanning is set.

5.3.2.4 Collect a Dark Scan.

5.3.2.5 Collect a Reference Scan. Note: A new Reference Scan must be collected if the stage is moved more than one field-of-view away from the position of the last Reference Scan, a new sample slide is introduced, or if changes are made to the optical settings (e.g., new objective, source intensity, Köhler illumination).

5.3.2.6 Move the fiber to be analyzed under the collection aperture. Collect a Sample Scan.

5.3.2.7 Collect at least five (5) spectra from each manufactured fiber sample to be compared. Collect at least ten (10) spectra from each natural fiber sample to be compared. Save the results in an appropriate electronic folder.

5.3.2.8 The Forensic Examiner may compare a single spectrum which best represents the samples collected or a mean spectrum of all the samples collected. Similar types must be compared (single spectrum compared to single spectrum or mean spectrum compared to mean spectrum). If spectra containing the mean are printed or saved electronically, the word “mean,” or the letters “mn,” must be part of the text describing the spectra.

5.3.2.9 For Legacy cases, all of the spectra generated will be printed and included in the case notes. In the event of large numbers of spectra, instead of printing the spectra, a CD may be burned with the data for inclusion in the case notes. For FA cases, the spectra will be imported into the Case Record Object Repository. Spectra must include the FBI Laboratory number(s), specimen number(s), the date of collection, and the operator's initials.

5.3.3 Comparison Criteria

5.3.3.1 Compare sample spectra within each region to determine if differences can be observed. Adjust the absorbance and wavelength scaling so each spectrum can be analyzed in its entirety. The position of the peak maxima, peak minima, peak width, and peak slope must all be considered.

5.3.3.2 Fiber samples are consistent in their microspectrophotometry spectra when no unexplainable differences are found.

5.4 FT-IR Analysis

If manufactured fibers exhibit the same microscopic characteristics and optical properties and color by MSP analysis (if appropriate), fiber samples may be analyzed utilizing FT-IR. One fiber per evidentiary item will be analyzed when applicable. The analysis involves two steps: a comparison of the known and/or questioned fibers to one another and an identification of the polymeric material. Natural fibers are not typically analyzed utilizing FT-IR.

5.4.1 Sample Analysis

5.4.1.1 Remove a portion of the fiber, place it on a diamond compression cell (or equivalent), and compress it. Remove one window, and place the remaining window and compressed fiber on the microscope stage. If flattening the fiber using a diamond compression cell is not appropriate, alternative sample preparation techniques may be used at the discretion of the Forensic Examiner. The sample preparation technique used will be recorded in the case notes.

5.4.1.2 Collect the sample spectrum followed by a background spectrum. Save the results in an appropriate electronic folder and print the spectrum for Legacy cases. Repeat for additional samples.

5.4.1.3 The remaining fiber may be dry-mounted on a glass microscope slide with a glass cover slip, or it may be mounted using Permount® mounting medium and a glass cover slip.

5.4.2 Sample Identification

The instrumental reference library may be used for polymeric identification of a fiber. When polymeric identification of a fiber is made, a copy of the library spectrum will be included in the case notes.

5.4.3 Comparison Criteria

5.4.3.1 Compare sample spectra within each region to determine if differences can be observed. Using the software, overlay the spectra to be compared. Adjust the transmittance and wavenumber scaling so that each spectrum can be analyzed in its entirety. The presence and position of all absorption peaks must be considered.

5.4.3.2 Two samples are consistent in their infrared spectra when no unexplainable differences are found.

5.4.3.3 Include a copy of the fiber spectra in the case notes.

5.5 Fiber Conclusions

5.5.1 If the fiber samples exhibit the same microscopic characteristics and optical properties utilizing the appropriate techniques outlined below, it can be concluded that the fibers are consistent with originating from the same source or another source comprised of fibers that exhibit the same microscopic characteristics and optical properties. A notation will be placed in the relevant portion of the case notes recording this fiber association.

5.5.1.1 For manufactured fibers, comparison microscopy, polarized light microscopy, fluorescence microscopy, microspectrophotometry and FT-IR on one fiber per evidentiary item will be attempted when applicable.

5.5.1.2 For natural fibers, comparison microscopy, polarized light microscopy, fluorescence microscopy and microspectrophotometry will be attempted when applicable.

5.5.2 If an unexplainable difference is observed between the fiber samples, it can be concluded that the fibers are not consistent with originating from the same source. This information will be recorded in the relevant portion of the case notes.

5.5.3 If there are insufficient microscopic characteristics or optical properties to determine whether or not the fibers are consistent with originating from the same source, the Forensic Examiner may determine that no conclusion can be reached. This information will be recorded in an appropriate place in the case notes.

5.5.4 If no fiber associations are found in a case, a summary statement may be made in the case notes recording this. This is left to the discretion of the Forensic Examiner.

5.5.5 Fibers may be identified as to their type (e.g., "The debris recovered from the tape is an acrylic fiber."). When fiber types are reported, all appropriate analytical techniques used to make a fiber identification must be performed and recorded the identification must be verified by a second qualified Forensic Examiner. In rare instances, it may not be possible to fully characterize a particular fiber. When reporting fiber identifications without full characterization, the Forensic Examiner will state the possible fiber identity (e.g., "an acrylic-like fiber") and provide a reason why full characterization was not conducted.

5.6 Fiber Verification

Fiber associations and/or identifications which are reported are verified by a second qualified Forensic Examiner. A fiber verification encompasses an examination of the microscopic characteristics and optical properties of a fiber obtained using comparison microscopy, polarized light microscopy, and fluorescence microscopy, and a review of all data produced using microspectrophotometry and infrared spectroscopy. These verifications are recorded by the signature of the verifying Forensic Examiner and the date of the verification on the Verification Form or in FA.

6 Calculations

$$\text{Birefringence} = \frac{\text{Retardation (nm)}}{\text{Fiber Thickness (nm)}}$$

7 Measurement Uncertainty

Not applicable.

8 Limitations

Fibers cannot be identified as originating from a particular source to the exclusion of all other possible sources comprised of fibers which exhibit the same microscopic characteristics and optical properties.

9 Safety

9.1 While working with physical evidence, laboratory personnel will wear appropriate protective attire.

9.2 Universal precautions will be followed.

9.3 No specific hazards are associated with the microscopic examination techniques performed.

9.4 Care should be exercised when using solvents such as Xylene and Xylene substitute.

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Rev. #	Issue Date	History
4	01/31/2019	Removed Trace Evidence from title. Added Section 5.5.3 Inconclusive result. Updated language used in Sections 5.2.2, 5.3, 5.3.1.2, 5.3.2.3, 5.4, and 5.5. Updated language in Section 5.4.2. Changed confirmation to verification in Section 5.6. Changed 'documented' to 'recorded' throughout.
5	02/10/2020	Updated SBAU-Trace group name throughout. Updated document titles throughout.

Approval

Redacted - Signatures on File

Trace Evidence Unit Chief: Date: 02/07/2020

Scientific and Biometric Analysis Unit Chief: Date: 02/07/2010

Hairs and Fibers Technical Leader: Date: 02/07/2010

Appendix A: *Trace Evidence Fiber Chart*

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Forensic Hair Examinations

1 Scope

This document describes the procedures for the microscopic examination, identification, and comparison of hair evidence by hair examiners in the Trace Evidence Unit (TEU) and the Scientific and Biometrics Analysis Unit – Trace (SBAU-Trace), the conclusions that can be reached, as well as the steps taken to prepare a hair for subsequent DNA analysis. These procedures apply to hairs that have been previously recovered from evidentiary items and have been mounted on glass microscope slides.

This document specifies the procedures for the typical examinations performed on hair evidence. The case scenario or contributor request(s) may result in a different examination approach. In those instances, information will be recorded in the case notes stating which examinations will be performed or omitted (e.g., evidence will only be examined for pubic hairs), as well as the rationale for the different examination approach (e.g., case scenario, contributor request.) The rationale will be recorded in the case notes or state where that information is recorded (e.g., incoming communication, communication log.)

2 Equipment/Materials/Reagents

- Comparison microscope, magnification range approximately 40x to approximately 600x
- Stereobinocular microscope, magnification range approximately 2x to approximately 40x
- Permount® mounting medium
- Xylene substitute, Xyless, or Xylene®
- Glass microscope slides and coverslips
- Pillboxes
- Forceps
- Spatulas
- Scissors
- Probes
- Scribes
- Microfuge tubes

3 Standards and Controls

Not applicable.

4 Sampling or Sample Selection

Not applicable.

5 Procedure

The microscopic examination of hairs requires the use of low magnification and high magnification. A stereobinocular microscope can be utilized to screen the glass microscope slides at low magnification, and a high magnification comparison microscope is necessary to compare the microscopic characteristics of hairs, typically using a magnification range from 40x to 400x.

5.1 Documentation of Hair Evidence

5.1.1 The following is a list of characteristics that may be used for identifying, classifying, and comparing hairs. This list is not all-inclusive; each characteristic may or may not be present in every hair. The type and number of characteristics recorded will be dependent on the characteristics present within the hair and the type of examination(s) conducted.

- Macroscopic
  - Color (in reflected light)
    - White
    - Blonde
    - Red
    - Brown
    - Black
  - Shaft form
    - Straight
    - Arced
    - Wavy
    - Curly
    - Twisted
    - Tightly coiled
    - Crimped
  - Shaft length range in centimeters or inches
  - Overall shaft thickness
    - Fine
    - Medium
    - Coarse
- Microscopic
  - Color (in transmitted light)
    - Color
      - Colorless (white)
      - Blonde

        - Red
        - Brown
        - Black
    - Natural pigmentation
        - Pigment size
            - Coarse
            - Medium
            - Fine
        - Pigment aggregation
            - Streaked
            - Clumped
            - Patchy
        - Pigment aggregate size
            - Large
            - Medium
            - Small
        - Pigment density
            - Absent
            - Uniform
            - Peripheral/lateral
            - One-sided
            - Random or variable
            - Central or medial
            - Pigment in cuticle
            - Banded
    - Color treatments
        - Dyes
        - Bleaches or lighteners
- Structure
    - Shaft characteristics
        - Diameter range in µm
        - Cross-sectional shape
            - Round
            - Oval
            - Triangular
            - Flattened
        - Shaft configurations
            - Buckling
            - Convoluting
            - Shouldering
            - Undulating
            - Splitting
            - Regular
    - Medulla

        - Absent
        - Continuous
        - Discontinuous
        - Fragmented
        - Opaque
        - Translucent
        - Relative width
        - Amorphous
        - Other (i.e., doubled, tripled)
- Cuticle
    - Present
    - Absent
    - Cuticle thickness
        - Thin
        - Medium
        - Thick
    - Outer cuticle margin
        - Flattened
        - Smooth
        - Serrated
        - Cracked
        - Looped
        - Irregular or other
    - Inner cuticle margin
        - Distinct
        - Indistinct
    - Cuticle color and clarity
        - Natural
        - Pigment
        - Dye
- Cortex
    - Cellular texture
        - Coarse
        - Medium
        - Fine
    - Ovoid bodies
        - Size
        - Distribution
        - Abundance
    - Cortical fusi
        - Size
        - Shape
        - Distribution
        - Abundance

- Ends
  - Proximal ends
    - Root present
      - Telogen (resting phase/club root)
      - Catagen (transitional phase)
      - Anagen (active growth phase/stretched root)
      - Sheathed
      - Follicular tag
      - Postmortem banding
      - Putrid
    - Root absent
      - Cut
      - Characteristics of decomposition
      - Crushed
      - Broken
  - Distal ends
    - Tapered tips (uncut)
    - Rounded or abraded
    - Square cut
    - Angular cut
    - Frayed
    - Split
    - Crushed
    - Broken
- Acquired characteristics
  - Artifacts
    - Nits or lice
    - Fungal tunnels
    - Insect bite marks
    - Debris
  - Damage
    - Environmental/chemical damage
    - Crushed
    - Burned/Singed
    - Cut
    - Broken
    - Frayed
    - Twisted
    - Tangled

5.1.2 The presence or absence of hairs can be determined based on a microscopic examination of the glass microscope slides containing debris recovered from an item (or group of items) of evidence. The absence of hairs will either be recorded in the case notes with a

statement such as “no hairs were found,” or the absence of any reference to hairs on an item of evidence implies that no hairs are present.

5.1.3 If animal guard hairs are present, and a determination regarding the type of animal can be made based on an examination of the microscopic characteristics, this information will be recorded in the case notes as appropriate. If the type of animal is not determined, the presence of animal hair will be recorded in the case notes as appropriate.

5.1.4 If human hairs are present, the characteristics of ancestry (European ancestry; African ancestry; and/or Asian or Native American ancestry) and somatic origin (body area) may be determined based on an examination of the microscopic characteristics of the hairs.

5.1.4.1 The following tables list characteristics observed when classifying hairs into ancestral groups and somatic origin. When a hair is classified into one of the following groups, the listed characteristics are observed unless otherwise noted. The characteristics in these charts are not all-inclusive.

Head Hair

	European Ancestry Head Hairs	**African Ancestry Head Hairs**	**Asian or Native American Ancestry Head Hairs**
Ancestral Characteristics	Oval cross-sectional shape; Even pigment arrangement	Flattened cross-sectional shape; Clumped pigment arrangement	Round cross-sectional shape; Patchy pigment arrangement
Somatic Origin Characteristics	Minimal observed diameter variation throughout	Regular observed diameter variation throughout	Little to no observed diameter variation

Pubic Hair

	European Ancestry Pubic Hairs	**African Ancestry Pubic Hairs**	**Asian or Native American Ancestry Pubic Hairs**
Ancestral Characteristics	Oval cross-sectional shape; Even pigment arrangement	Flattened cross-sectional shape; Clumped pigment arrangement	Round cross-sectional shape; Patchy pigment arrangement
Somatic Origin Characteristics	Coarse diameter through root; irregular observed diameter variation throughout; buckling; prominent medulla	Coarse diameter through root; irregular observed diameter variation throughout; buckling; prominent medulla	Coarse diameter through root; irregular observed diameter variation throughout; buckling; prominent medulla

Facial Hair

	European Ancestry Facial Hairs	**African Ancestry Facial Hairs**	**Asian or Native American Ancestry Facial Hairs**
Ancestral Characteristics	Even pigment arrangement	Clumped pigment arrangement	Patchy pigment arrangement
Somatic Origin Characteristics	Coarse diameter; triangular cross-section	Coarse diameter; triangular cross-section	Coarse diameter; triangular cross-section

5.1.4.2 The examiner will describe hairs which exhibit characteristics of more than one ancestry as exhibiting characteristics predominantly of the ancestry which contributed the majority of the observed microscopic characteristics; however, if a predominant ancestry cannot be determined, the examiner will describe the hair(s) as exhibiting mixed ancestral characteristics.

5.1.4.2.1 The case notes will indicate a characteristic(s) from the non-predominant ancestral group(s) observed.

5.1.4.3 If the microscopic characteristics do not allow for ancestry determination to be made (e.g., white hairs, opaque hairs), the hair will not be classified with respect to ancestry.

5.1.4.4 The presence of human head hairs and pubic hairs and their characteristics of ancestry will be recorded in the case notes. The presence of human facial hairs and their characteristics of ancestry will be recorded in the case notes, as appropriate. These hairs can be identified individually or collectively for each evidentiary item or group of items.

5.1.4.5 Head hairs, pubic hairs, and facial hairs that also exhibit characteristics of another somatic origin may be considered a transitional hair. This will be recorded in the case notes and the case notes will indicate a characteristic(s) observed from another somatic origin.

5.1.4.6 If human hairs do not exhibit characteristics of head, pubic, or facial somatic origin, these hairs will be described as body hairs, hair fragments, or fringe hairs.

5.1.4.6.1 Body hairs are typically not classified to a specific ancestral group or somatic origin. If body hairs will be further described as exhibiting characteristics of a limb hair, axillary hair, chest hair, or eyebrow/eyelash hair then the characteristics observed in the hair to support further classification of body hairs will be recorded in the case notes. If body hairs will be classified to a specific ancestral group, then characteristics observed in the hair to support ancestral classification of body hairs will be recorded in the case notes.

5.1.5 Additional microscopic characteristics present in hairs will be recorded as appropriate.

5.1.5.1 Hairs with a stretched root may be described as exhibiting characteristics of having been forcibly removed.

5.1.5.2 Damage to hairs may be described as exhibiting characteristics of having been cut, broken, crushed and/or burned.

5.1.5.3 A hair may be described as artificially treated (e.g., dyed, bleached) or as exhibiting characteristics of artificial treatment.

5.1.5.4 A hair may be described as exhibiting characteristics of apparent decomposition (e.g., postmortem root banding).

5.2 Hair Comparisons

5.2.1 Suitability

5.2.1.1 A determination of the suitability for meaningful microscopic comparison purposes will be made for hairs examined. A statement will be added to the case notes when the determination is made that a hair is either of limited value or not suitable for meaningful microscopic comparison purposes.

5.2.1.2 Hairs that exhibit sufficient microscopic characteristics for comparison are suitable for meaningful microscopic comparison purposes. Typically, head and pubic hairs are the only human hairs that fall into this category. Typically, guard hairs are the only animal hairs that fall into this category. These hairs can be compared to known hair samples and all possible conclusions can be reached.

5.2.1.3 Hairs that exhibit fewer distinguishing microscopic characteristics for comparison (e.g. white head hairs, transitional pubic hairs) may be determined to be of limited value for meaningful microscopic comparison purposes. These hairs can be compared to known hair samples, however, only exclusion and inconclusive results can be reached from a comparison.

5.2.1.4 Hairs that do not exhibit sufficient microscopic characteristics are not suitable for meaningful microscopic comparison purposes. These hairs will not be compared to known hair samples.

5.2.1.5 When a known hair sample does not contain sufficient hairs to demonstrate the possible range of variation in microscopic characteristics (i.e., limited known sample) a determination will be made as to the suitability for meaningful microscopic comparison purposes. This determination will be recorded.

5.2.1.5.1 It may be possible to reach an inclusion conclusion if the microscopic characteristics in a questioned hair are represented in the hairs in the limited known hair sample.

5.2.1.5.2 If the microscopic characteristics in a questioned hair are microscopically dissimilar

to the hairs in a limited known hair sample, an exclusion conclusion will be reported, along with a statement indicating that the known hair sample was of limited suitability.

5.2.1.5.3 If the microscopic characteristics in a questioned hair exhibit both similarities and differences to the hairs in a limited known hair sample, an inconclusive conclusion will be reported, along with a statement indicating that the known hair sample was of limited suitability.

5.2.2 Comparison Method

5.2.2.1 Comparison microscopy will be used to compare all of the microscopic characteristics present in the questioned hair(s) to the hairs in the known hair sample.

5.2.2.2 The comparison process will involve a direct comparison of the questioned hair and the known hair sample along the entire length of the hair utilizing all of the microscopic characteristics which are present in the hair. Questioned human hairs will be compared to known human hair samples from the same somatic origin. Animal guard hairs recovered from evidentiary items will be compared to known samples of animal guard hairs.

5.2.2.3 There is no minimum number of microscopic characteristics necessary to reach a conclusion. All of the characteristics present in the hairs will be considered as part of the comparison process.

5.2.2.4 The presence, absence, appearance, and distribution of characteristics in the hairs being compared are important considerations. The variability of hair characteristics between individuals allows for meaningful conclusions.

5.2.2.5 A meaningful difference between a questioned hair and a known hair sample is defined as a characteristic that is found in the questioned hair that cannot be found in the known hair sample.

5.3 Hair Comparison Conclusions

5.3.1 Inclusion

5.3.1.1 An inclusion can be determined when all of the microscopic characteristics in the questioned hair are represented in the known hair sample. Hairs microscopically consistent with the source of a known sample, found on items related to the source of the known sample (based on case information provided by the contributor) will not be considered an inclusion.

5.3.1.2 If the questioned hair is microscopically consistent with the hairs in the known hair sample then the source of the known sample can be included as a possible source of the questioned hair.

5.3.1.3 When a microscopic comparison of human hairs results in an inclusion, the following statements will follow the reporting of the conclusion:

> The comparison of microscopic characteristics in hairs does not constitute a basis for personal identification and the number of individuals who could be included as a possible source of a specific hair is unknown. The inclusion of an individual as a possible source of the hair by comparison of microscopic characteristics should be evaluated in conjunction with the conclusion of DNA analysis, when available.

5.3.1.4 When microscopic comparison of animal hairs results in an inclusion, the following statements will follow the reporting of the conclusion:

> The comparison of microscopic characteristics in hairs does not constitute a basis for identification. Animals of similar breed and color may also exhibit the same microscopic characteristics.

5.3.1.5 A notation will be placed in the relevant portion of the case notes recording an inclusion.

5.3.2 Exclusion

5.3.2.1 An exclusion can be determined when a meaningful difference is observed between the questioned hair and the known hair sample.

5.3.2.2 If the questioned hair is microscopically dissimilar to the hairs in the known hair sample then, based on the known hair sample provided, the source of the known hair sample cannot be included as a possible source of the questioned hair.

5.3.2.3 A notation will be placed in the relevant portion of the case notes recording a hair exclusion. The case notes will indicate a characteristic(s) observed which is microscopically dissimilar to the hairs in the known hair sample.

5.3.3 Inconclusive

5.3.3.1 An inconclusive conclusion can be determined either when a questioned hair exhibits both similarities and slight differences to the hairs in the known hair sample, the questioned hair is microscopically similar to the known hair sample, but is of limited value for meaningful microscopic comparison purposes, or the known hair sample provided is of limited value for meaningful microscopic comparison.

5.3.3.2 When one of these conditions are met, then no conclusion can be reached as to whether the source of the known hair sample can or cannot be included as a possible source of the questioned hair.

5.3.3.3 A notation will be placed in the relevant portion of the case notes recording an inconclusive result of the hair comparison. If the conclusion is that the questioned hair exhibits similarities and slight differences, the case notes will indicate the slight difference(s) observed in the microscopic characteristics present.

5.4 Hair Blind Verifications and Verifications

5.4.1 All hair inclusions will be blind verified by a second qualified examiner. At the discretion of the examiner or technical reviewer, other hair comparison conclusions may also be blind verified by a second qualified examiner. When other hair comparison conclusions are selected for blind verification, a notation will be made in the case notes identifying which hair was selected for blind verification.

5.4.1.1 When hair comparison conclusions are blind verified, the second qualified examiner will not know the conclusion of the primary examiner and will not have been consulted by the primary examiner during the examination and comparison process.

5.4.1.2 The primary examiner will identify the items to compare and notify their supervisor or Technical Leader of the need for a blind verification. The supervisor or Technical Leader will assign a second qualified examiner to perform the blind verification.

5.4.1.3 When available, multiple known samples will be provided to the blind verifying examiner.

5.4.1.4 For blind verifications, notes supporting the conclusion of the blind verifier will be taken and added to the examination records.

5.4.2 Other hair examination and comparison conclusions may be verified by a second qualified examiner at the discretion of the primary examiner or technical reviewer (e.g., postmortem root banding, appearance of damage, similarities and differences).

5.4.2.1 The primary examiner will identify the item and hair conclusion and notify their supervisor or Technical Leader of the need for a verification. The supervisor or technical leader will assign a second qualified examiner to perform the verification.

5.4.3 Blind verifications and verifications will be recorded by the signature of the verifying examiner and the date on a Blind Verification/Verification Form for Legacy cases or recorded in Forensic Advantage (FA). Any disagreements between the primary examiner and verifying examiner will be addressed under the FBI Laboratory Operations Manual - *FBI Laboratory Practices for Resolution of Scientific or Technical Disagreement*.

5.5 Preparing Hairs for DNA analysis

5.5.1 Human hairs associated to a known hair sample will be assessed for DNA examinations. Other hairs may be submitted for DNA analysis at the discretion of the examiner.

5.5.2 Nuclear DNA analysis may be conducted on hairs in the anagen growth stage or hairs with adhering tissue. Mitochondrial DNA analysis may be conducted on hairs without roots or on hairs in the telogen growth stage with no tissue adhering to the root.

5.5.3 Removal of the hair from the glass microscope slide is critical for DNA analysis. Precautions will be taken so the questioned hair is not contaminated with foreign debris and/or fluids. The procedure for removing hairs from glass microscope slides for DNA analysis is as follows:

5.5.3.1 Prior to removing the hair, a photograph may be taken of the root end of the questioned hair.

5.5.3.2 The hair will be removed from the slide.

5.5.3.3 The hair will be rinsed in Xylene substitute or equivalent solvent to remove any adhering mounting media.

5.5.4 For nuclear DNA analysis, the root portion of the hair will be removed and placed in a clean microfuge tube or dry mounted on a glass microscope slide. For mitochondrial DNA analysis, an approximately 2 centimeter portion of the proximal end of the hair, when available, will be removed and placed in a clean microfuge tube, on an adhesive pad, or another acceptable container.

5.5.5 The hair will be designated by the next available derivative of the "Q" for Legacy cases (e.g., Q2.1) or item number for cases in FA (e.g., Item 2-1).

5.5.6 The remaining portion of hair, if applicable, will be maintained on the original slide, in a microfuge tube, in a pillbox, or another acceptable container.

6 Calculations

Not applicable.

7 Measurement Uncertainty

Not applicable.

8 Limitations

The comparison of the microscopic characteristics in human hairs does not constitute a basis for personal identification. The inclusion of an individual as a possible source of the hair by comparison of microscopic characteristics should be evaluated by the contributor in conjunction

with the conclusion of DNA analysis, when available. Hair examinations may be limited where a considerable length of time exists between the deposition of questioned hairs and the collection of known hair samples.

The comparison of the microscopic characteristics in animal hairs does not constitute a basis for identification. Animals of similar breed and color may also exhibit the same microscopic characteristics.

9 Safety

9.1 While working with physical evidence, laboratory personnel will wear appropriate protective attire.

9.2 Universal precautions will be followed.

9.3 No specific hazards are associated with the microscopic examination techniques performed.

9.4 Care should be exercised when using solvents such as Xylene substitute.

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- Abbreviations, Trace Evidence Quality Manual (current version).

- FBI Laboratory Operations Manual.

Rev. #	Issue Date	History
6	06/20/2018	Removed 'Trace Evidence' from title. Updated Scope to specify typical examinations section. Updated Equipment/Materials/Reagents list. Added 'or Sample Selection' to Section 4 title. Modified language throughout Sections 5 & 8 to clarify. Changed 'case notes' to 'examination notes' throughout. Moved Section 5.1.1 and updated section of list 'Proximal ends.''Renamed ancestral groups to European, African, and/or Asian or Native American. Added Section 5.1.4.1 and charts noting ancestral & somatic origin characteristics. Added Sections 5.1.4.2 through 5.1.4.4.1. Added catagen to 5.1.7. Added Section 5.2.1 on Suitability. Combined animal hair conclusions with human hair conclusions, separated conclusions by inclusion, exclusion, and inconclusive, and added criteria for each. Added requirement to record an observed difference(s) for exclusion and an observed slight difference(s) for similarities and differences. Separated out Blind Verifications and Verifications for clarity. Added requirement to note hair selected for blind verification for other conclusions. Added 'probative' to explanation of blind verifications. Updated Section 5.6. Added animal hair to limitations. Renumbered document to accommodate changes.
7	02/10/2020	Updated SBAU-Trace group name throughout. Changed 'examination notes' to 'case notes' throughout.

Approval

Redacted - Signatures on File

Trace Evidence Unit Chief: Date: 02/07/2020

Scientific and Biometrics Analysis Unit Chief: Date: 02/07/2020

Hairs and Fibers Technical Leader: Date: 02/07/2020